

State of California  
Pete Wilson, Governor  
The Resources Agency  
Douglas P. Wheeler, Secretary for Resources  
DEPARTMENT OF FISH AND GAME  
Boyd Gibbons, Director

## SB 34 DELTA LEVEES MITIGATION GUIDANCE DOCUMENT

Region 2  
Delta Levees Project  
1701 Nimbus Road  
Rancho Cordova, CA 95670



—— May 1995 ——

## FOREWARD

The Memorandum of Understanding (MOU) (Appendix A) regarding SB 34 fish and wildlife protection, between the California Department of Water Resources (DWR), the Reclamation Board, the California Department of Fish and Game (DFG), and the Resources Agency, directs the implementation of the "no net long-term loss of habitat" policy of SB 34, the Delta Flood Protection Act of 1988. This "Mitigation Guidance Document" provides tools and information to districts for the planning and implementation of this directive.

The MOU directs DWR, DFG, and the Reclamation Board to "encourage and seek out" mitigation in the following order of priority:

1. Avoid Adverse Impacts
2. Mitigate On-Site
3. Mitigate Off-Site

These priorities will be observed by the DFG when using this mitigation guidance document.

These guidelines were developed for the SB 34 program. They include information on required mitigation associated with losses of habitats on levees. Some of the information is based on previous documents developed by the State of California. The documents from which the information was taken include the following:

Delta Mitigation Guidelines which were developed for the Delta Wetlands Project (revised March 23, 1992)

Statewide Fish Screening Policy (approved by the Director, DFG, on March 9, 1994)

Vegetation Management Guidelines for Local, Nonproject Delta Levees (concurred with by the California Office of Emergency Services, April 15, 1994 and by the Federal Emergency Management Agency on April 22, 1994)

Official Policy on Conservation Banks (signed by the Secretaries for The Resources Agency and the California Environmental Protection Agency, April 7, 1995)

The guidelines presented here should be used when avoidance is impossible and all practical measures to reduce impacts have been incorporated.

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## **I. INTRODUCTION**

This document has been set up to help you understand the mitigation process for SB 34 funded projects. Flow charts (Figures 1 and 2) will help you through aspects of the SB 34 regulatory process.

### **A. Mitigation Requirement for Typical SB 34-Funded Projects**

For ease of use, we divided up the potential impacts to habitat by how they may be affected by typical levee repair and rehabilitation projects. We divided projects into the following categories: waterside erosion repair, waterside toe berm fill, levee crown work, back slope fill, vegetation control, and seep ditch clean out. Of these, levee crown work is the only one that, by its nature, would almost never require mitigation. As such, no further discussion will be included for crown work. Each of the other categories is discussed below.

### **B. Waterside Erosion Repair**

Typically, these projects repair short sections of levee that are eroding, slipping, or subsiding. They may not require mitigation. Avoidance techniques should be considered here. Examples would be placing rock around existing trees and leaving root systems intact when trees must be removed. Affected habitat types are usually scrub-shrub, riparian forest, and shaded riverine aquatic habitats.

If avoidance is impossible, mitigation can be difficult. Preferred mitigation for impacts on the waterside slope are always waterside sites. Such mitigation sites are rare in the Delta and expensive to construct. An inexpensive alternative would be to plant certain tree species on repaired levee slopes. Districts should also consider repairing small erosion sites by constructing small berms at the toe of the sites, to be planted with woody riparian vegetation.

All waterside projects have the potential to affect several special status species. These sites should be surveyed carefully prior to reconstructing the levee slope. If special status species are located near the site, the DFG must be contacted. These plant species should be avoided. Those plants that cannot be avoided may have to be transplanted and cultivated. For additional information on how to deal with special status species, see Section VII. E.

### **C. Waterside Toe Berm Fills**

These projects may affect shrub-scrub, riparian forest, shaded riverine aquatic, and freshwater marsh habitats. They often require mitigation. These projects have many of the same problems as those for erosion repair described above. In addition, many of the

avoidance techniques suggested above cannot work due to the amount of construction materials which must be used.

However, one potential mitigation method becomes available due to the very nature of the projects. If the project creates a broad stable levee with a waterside berm, the berm may be planted with trees to create shrub-scrub, riparian forest, or shaded riverine aquatic habitats. Project designers should evaluate these sites for their potential to support such habitats. These berms may be large enough to create habitat for the project itself, and also additional habitat which could be used to mitigate for past or future projects on the rest of the island.

As for the erosion sites described above, these sites must be examined for special status species before construction can begin.

#### **D. Backslope Fills**

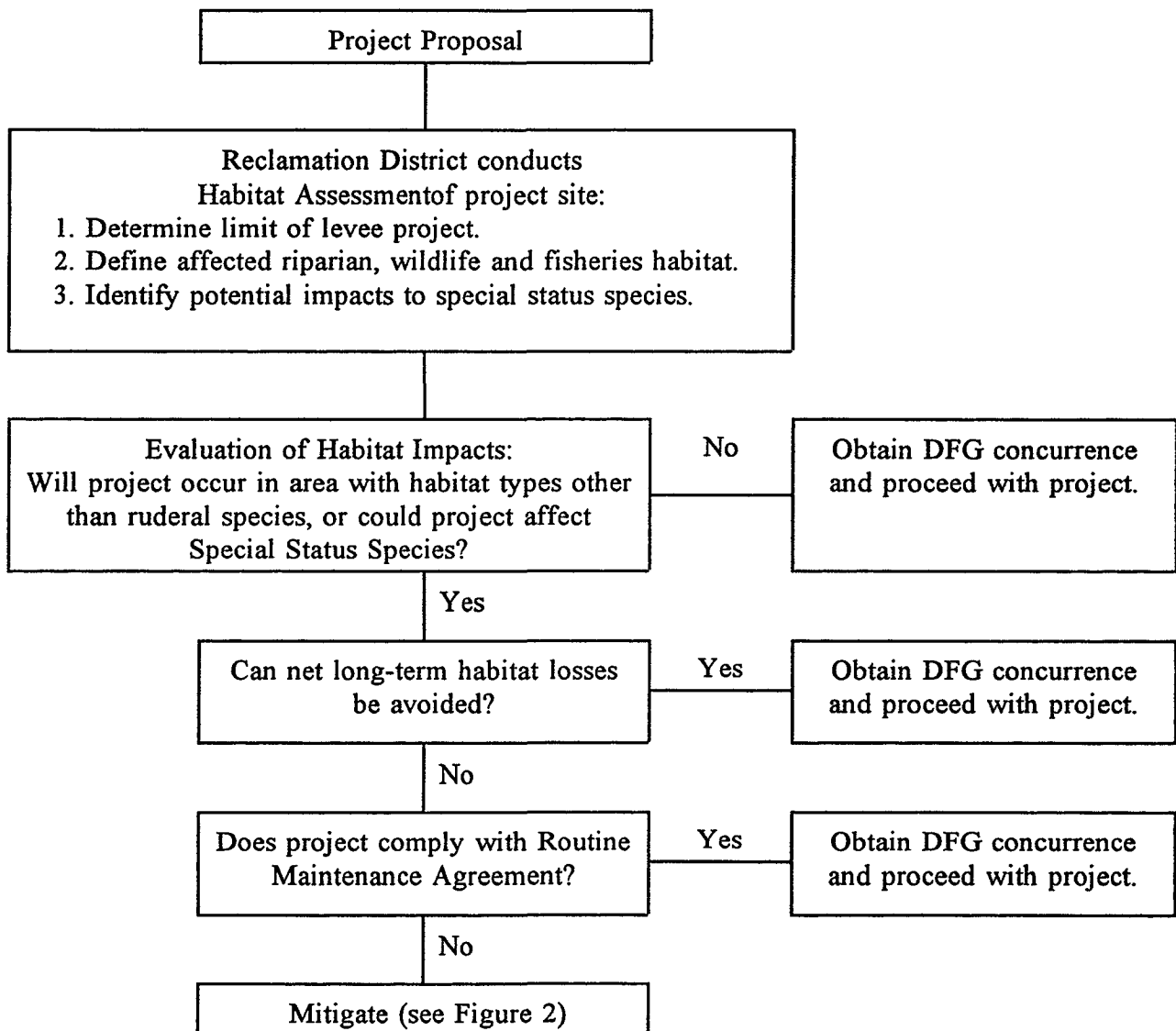
Backslope fill projects have the potential for affecting scrub-shrub, riparian forest and freshwater marsh habitats. These projects are often large in size and can fill wetland areas next to and within the toe ditches. Avoidance methods described earlier in this document are often difficult to carry out because construction materials are placed directly on the habitat and vegetation cannot survive.

Fortunately, mitigation for landside projects is often easier to implement than for waterside projects. On-island mitigation sites are easier to find and often simpler to establish. Some mitigation may occur through regrowth when a new toe ditch is constructed. The newly adopted "vegetation management guidelines" require a clean backslope, but this will likely generate a mitigation requirement. An opportunity to provide mitigation may be found on the waterside lower slope where the guidelines allow vegetation.

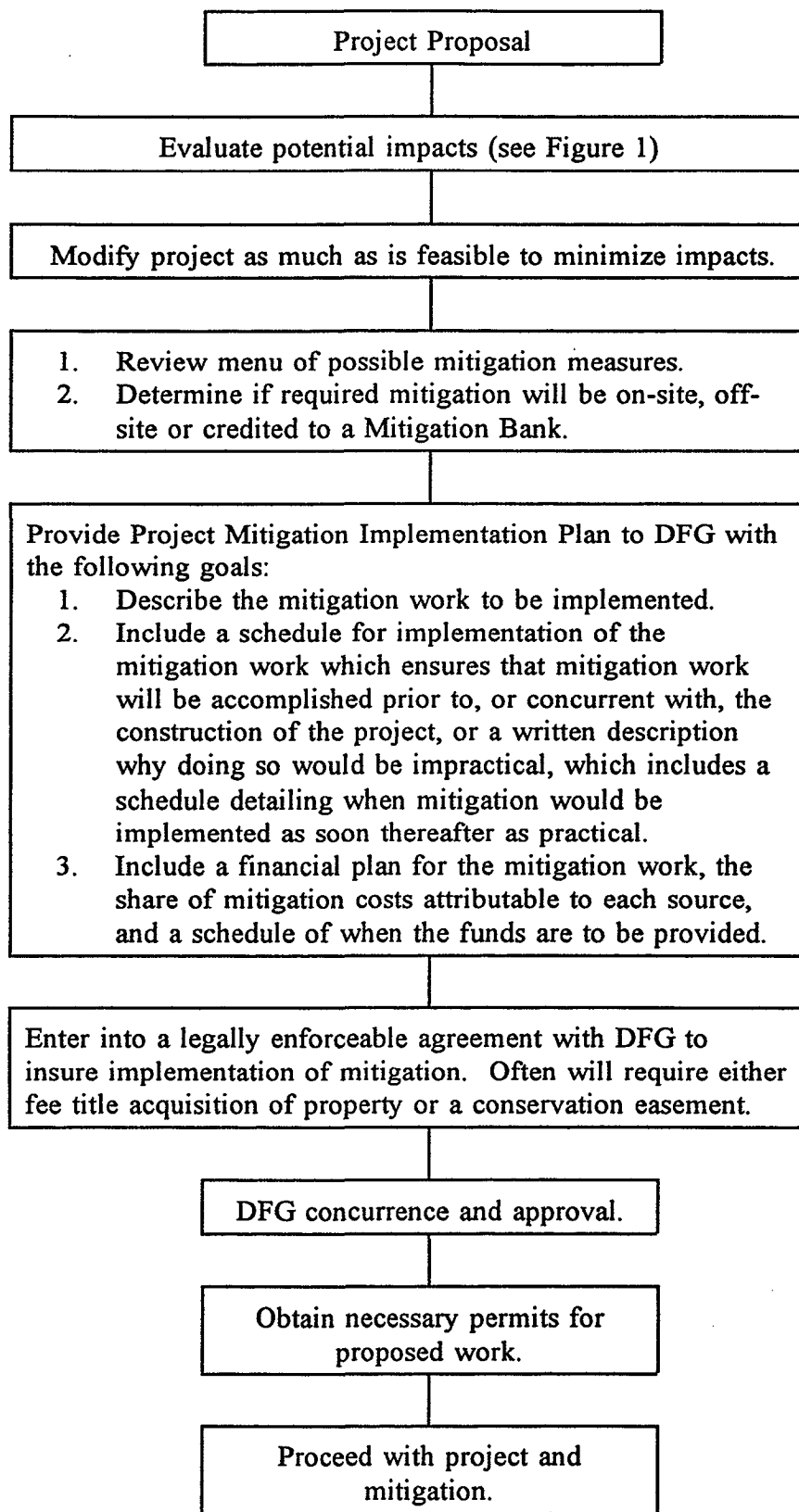
#### **E. Vegetation Control**

Mitigation is sometimes required for vegetation control projects, especially when large blocks of vegetation are removed at one time. Routine maintenance agreements allow for the removal of very small and very large trees for levee maintenance. Large trees are replaced off the levee. Small vegetation regrows on-site. Some islands with a large amount of scrub-shrub and riparian forest habitats have entered into modified routine maintenance agreements. These allow for removal of any common vegetation on the levee slopes as long as the total amount and value of habitat does not fall below a certain level as indicated in a habitat assessment. One method for eliminating, or at least reducing, the need for mitigation is to remove only a portion of the total amount of vegetation on the island in any given year.

**Figure 1. Project Evaluation Flow Chart**



**Figure 2. Mitigation Process**





Districts should refer to the Vegetation Management Guidelines to determine where vegetation retention on the levee is appropriate thereby avoiding a mitigation requirement. On-levee mitigation may be placed according to the same guidelines.

#### **F. Seep Ditch Cleanout**

Mitigation is sometimes required for cleaning short portions of a regularly maintained toe ditch. Habitat in such ditches is usually freshwater marsh, which recovers quickly. Mitigation can be required if exceptionally long sections of ditch are cleaned in one year, if a ditch with woody riparian vegetation growing in it is cleaned, or a permanent loss of a wetland occurs.

## II. AVOIDANCE OF IMPACTS ON LEVEES

The avoidance of on-site impacts is the highest mitigation priority. There are several construction methods which can be used to avoid or minimize impacts to habitat. Some are experimental; some have been implemented in various locations in the Delta. The following maintenance techniques are biologically beneficial, but the structural problems associated with these alternatives need to be determined by persons familiar with levee engineering:

1. Implement the Vegetation Management Guidelines for Local Nonproject Levees in the Sacramento-San Joaquin Delta (Appendix B). This involves working with DWR levee inspectors to allow for more vegetative growth to occur along the lower waterside slopes of the levees (Figure 3). Trim the lower branches of alders, native walnuts, and larger willows to allow inspection (Figure 4). Trees on stable sites should be left in place when not a threat to the levee. A written agreement may allow more or less continuous levee maintenance, offset by vegetation replacement by fast-growing woody species. Long-term losses, contrary to the program's mandate of "no net long-term loss" would occur if avoidance of slow-growing vegetation such as oaks was not possible.
2. Rapidly sprouting plants such as willows may be cut off at the ground line and root systems left intact. Plants will rapidly resprout if there is no follow-up control. Plant loss will be considered short-term and no mitigation will be required.
3. Place riprap carefully around existing trees.

Other techniques, while not specifically impact avoidance, may reduce biological impacts. For instance, projects may be planned far enough in advance that levees that are currently protected by vegetated berms could be stabilized before the levees themselves are in danger of eroding away.

The use of palisades or similar structures involves the placement of a series of nearshore pilings with fabric placed between the pilings to collect sediment carried in suspension by the current. The goal is to protect the shoreline from waves and to create a berm area between the pilings and the shoreline where vegetation can become established.

Some or all of these avoidance methods must be considered before finalization of a workplan.



Figure 3. Vegetation on levees.

Trees growing on the water-side of levees that are not a threat to their integrity are left in place and trimmed to allow for levee inspections.



Branches are trimmed the first year by hand labor. Branches hanging over the water are not trimmed.

The top 5 feet of the water-side levee can be kept clear of all vegetation, except grasses and low herbs. Control measures in subsequent years can be limited to the top 5 feet of the levee and to areas between the trimmed trees to discourage shoots, low branches, and shrubs.



Figure 4. Trimming lower branches of trees.

### **III. MITIGATION: GENERAL**

#### **A. Mitigation Determination**

Estimate expected damages to fish and wildlife habitat when avoidance of "net long-term" impacts is infeasible. Develop mitigation for these impacts. A number of considerations arise:

1. What kinds of projects are likely to require mitigation?
2. How much and what type of mitigation is necessary?
3. Can out-of-kind mitigation be created?
4. Where is the best place for mitigation to be established?
5. What techniques can be used to establish those mitigation sites?
6. Can a mitigation bank be established to mitigate for many smaller impacts?

#### **B. Replacement Criteria**

The interagency MOU requires that the Habitat Evaluation Procedure (HEP) process, or similar analysis, be used for the evaluation of habitat within the Delta. The traditional HEP is a difficult and time consuming process. It is unlikely to be used for an ongoing program like SB 34 which funds many mitigation projects.

The DFG determines the amount of mitigation required for each project by looking at the following:

1. Size: In general, the larger the habitat affected the more valuable it is. More acres of mitigation are normally required for each acre affected.
2. Quality: High quality habitat usually requires a greater mitigation ratio. Is the habitat adjacent to larger wildlife or fisheries habitats? Is the habitat relatively rare? Does this habitat type support a large number of fish and wildlife species. Are special status species found in the habitat type?
3. Age: The longer it takes to establish a plant and animal community the greater the ratio required to replace it. Replacement values are discounted against reestablishment time.

Mitigation should occur as near to the project as possible. It should create the same kind of habitat which was lost. Out-of-kind habitat may require a higher replacement ratio.

#### **C. Mitigation Costs and Financing**

1. Up to 100% of the costs of required mitigation may be reimbursed through the SB 34 program if sufficient money is available.
2. Any costs for property rights will not exceed the fair market value of the property.
3. Operation and maintenance (O&M) costs are reimbursable in this program. O&M activity is expected to be minimal after the first five years or so, or when mitigation values are established.

#### **D. Mitigation Banks**

The DFG is following the provisions of the "Official Policy on Conservation Banks" (Appendix C). Mitigation banks can be established on the interior of Delta islands, on attached waterside berms, on dredge remnant islands, and on unaltered small channel islands. Banks can mitigate for past and future impacts, and can be used by more than one Reclamation District. Implementation of the newly adopted Vegetation Management Guidelines may allow the levees themselves to become a form of mitigation bank.

#### **E. Mitigation Agreements**

"Legally enforceable" mitigation agreements are required to provide mitigation in perpetuity. They may be combined with agreements developed under Fish and Game Code Section 1601. The mitigation agreement requirement is based on the Memorandum of Understanding for the SB 34 program. Each Mitigation Agreement includes a Mitigation Plan which outlines the process for constructing the mitigation site, describes the planting plan, and outlines monitoring methods. The Mitigation Agreements also include a conservation easement or similar document.

#### IV. MITIGATION: SITE DESIGN

##### A. Modifications to District Islands

This discussion concerns islands greater than about 100 acres in size. Mitigation banks can be established on these islands, replacing farming, or supplementing wildlife or hunting areas. In addition, other suggestions are made to provide "food for thought".

1. Returning narrow "fingers" of Reclamation District land to tidal action would involve building cross levees across the narrow necks of District land and breaching the remnant levee to return the area to tidal action. Such action was taken in the COE's Cache Slough Mitigation Project.
2. Entire delta islands can be acquired by the DFG, the Nature Conservancy, or other entity. The interior of the island can be modified to provide SRA habitat if the levees are breached.
3. A berm can be created along the edge of the levee. Place riprap or some other armoring material parallel to the levee. Fill the area between the armor and the toe of the levee with soil. Riparian vegetation can be planted on this berm (Figures 5 and 6). This method of habitat creation was implemented in 1992 along Staten Island by the M & T Staten Island Ranch.
4. Groins can be constructed along a levee. They should be constructed no closer than 50 feet apart. Log booms can be placed in front of the groins to deflect wave action.
5. Pilings can be placed along the shoreline. A permanent fabric or netting material can be strung between the pilings. Fill material or trees, snags, or other woody debris can be placed behind the fabric. Woody materials provide fish habitat. Fill material can be planted with trees.
6. Set-back cross levees can be built on the interiors of existing levees. The old levee and isolated land would be left as wildlife habitat.
7. Cardboard tubes 2 to 3 feet in diameter used in building construction may be suitable for levee protection. They can be placed in riprap areas and filled with soil. Trees or shrubs can be planted in them. These tubes were successfully used along Los Trampas Creek in Lafayette, California.
8. Biotechnical slope stabilization methods were used in the COE's Cache Slough project. They consisted of staking brush and reed rolls along the toe of the slope which break up the wave energy along the shoreline.

## **B. Enhancement of Channel Islands**

Channel islands can be developed to provide shaded riverine aquatic (SRA) habitat, emergent marsh, and shoals. Those to be enhanced should be selected upon evidence that the islands are eroding from wave action (Figure 7). This evidence may be provided from aerial photos. Some enhancement methods would be:

1. Fill material can be placed around the perimeter of an island (Figure 8). Indentations should be placed along the islands wherever possible to increase the linear distance of shoreline and to maximize the quality of SRA created. All or portions of the added material should be lined with riprap or other material to help protect the bank from wave and tidal action.
2. Fill material can be placed on the interior of a channel island. There is photographic evidence that many of the islands in the Delta have eroded over time. The remaining portions of these islands are often very low in elevation and contain only one habitat type. Raising the elevation of at least parts of the island and planting it with trees would help stabilize the island from wave action and allow more of a variety of habitats.
3. Other materials which can be used for stabilization include cellular plastic "honeycomb" structures, coconut rolls and mats, and willow wattles.

Each cell of a "honeycomb" mat is filled with soil and planted with vegetation. This type of material appears especially promising for stabilizing in-channel islands where there is a flat gradient.

Coconut mats and willow wattles provide temporary protection from low energy wave erosion. Willow wattles will sprout and promote vegetation establishment.

All of these systems may work best in areas where heavier systems might sink into the peat soils.

## **C. Alternative Bank Stabilization Methods on Levees**

Other stabilization materials besides riprap may maximize vegetation growth and retention on the levees (Delta Levee Slope Protection Alternatives, DWR, 1990). Two of these were tried in the Delta in 1992.

1. Armorflex® (Figure 9) -- Cellular concrete blocks are cabled together and anchored to the top of the bank. Armorflex® works on slopes with gradients up to 1:1. The cable will support the blocks if the levee slopes are undermined. Trees, grasses, shrubs, and other vegetation can grow through openings in the blocks.





Figure 5. Eroding levee berm.



Figure 6. Dredge berm created along a levee. A low-water rock prism protects the berm and planted vegetation from wave erosion.



Figure 7. Channel island showing evidence of wave erosion.



Figure 8. Dredge material being placed along the perimeter of a channel island.

Armorflex® has the potential for lasting much longer than riprap. It has a higher initial cost, but it may have a reduced long term cost. Armorflex® was placed at McCormack-Williamson and Holland Tracts to demonstrate its potential. Vegetation is growing well in the blocks, including willows.

2. Tri-lock® (Figure 10) -- This is a non-cabled, interlocking concrete block system. It appears to be best suited for locations where there is a shallow (flatter than 2:1) slope. It has the same potential for allowing vegetation growth as Armorflex®. In addition, it may have a lower initial (and possibly lower long term) cost. Demonstration projects have also been implemented with Tri-lock® at McCormack-Williamson and Holland Tracts. Preliminary results indicate that this material will support vegetation growth as well. However, it may not conform to variable settlement of fill material.

Proprietary structures can be used along shorelines where they will reduce shoreline erosion from boat induced wave action. Their use may reduce the need for traditional armoring on the levee. They may also provide cover for fish. The use of floating logs, anchored by chains, has been suggested for shoreline protection in the Delta. This concept is being tested at Sycamore Island, in the South Fork Mokelumne River.

The methods discussed above may also work on channel islands.

#### **D. Mitigation Behind Levees**

Mitigation behind levees can offset net long-term losses to scrub-shrub, riparian forest, and freshwater marsh habitats. The following methods can be used to create this interior mitigation:

1. Conversion of agricultural crops to wildlife habitat (Figure 11). Habitat management areas may be created by land shaping and irrigation. Willow wattles will encourage rapid stand creation and soil stabilization.
2. 400 foot wide easements along the interior of the levee may be developed into wildlife habitat. These easements could tie into island drainage systems. This could reduce soil subsidence and help provide levee stability.

#### **E. Creation of SRA Habitat**

Shaded riverine aquatic habitat is valuable for both fish and wildlife. This habitat type is what most people think of when they talk about the values of the Delta. However, there are many technical and administrative problems associated with SRA development. These include cost, obtaining fill material, development techniques and permits.

The costs of SRA mitigation are greater than for scrub-shrub or riparian forest. Cost estimates for creation of SRA habitat in the Delta have been around \$100 to \$200 per lineal foot of shoreline.

Methods for the establishment of SRA habitat are still under development. Some projects were developed by the Corps of Engineers as part of the Sacramento River Bank Protection Project, phase I, in the late 1970's. Three additional sites were constructed in Steamboat Slough in phase II of this project in 1991. Two other privately funded demonstration projects were constructed in 1992 and 1993. These private sites will be monitored over the next few years by SB 34 staff.

In addition, SRA mitigation, unlike mitigation for other habitat types, will often require an exchange of habitat. On the interior of the islands, where the proposed mitigation sites may be in farmland, there usually is only a moderate habitat value to be lost or modified before conversion to mitigation habitat. In the case of SRA mitigation sites on channel islands, the sites are already vegetated and provide high habitat values. And even along levees, mitigation techniques involve modification of existing habitat. This requires a comparison of "before and after" habitat values.

SRA habitat mitigation will usually require either a nationwide or an individual COE permit for working in water. DFG and DWR SB 34 personnel have met with staff of the agencies which will be involved in the COE permit review process, to determine their concerns about establishment of SRA mitigation habitat in the Delta. These concerns include: 1) Documentation of the need for the stabilization of channel islands; 2) Possible temporary or permanent loss of channel island habitat displaced by the placement of rock, soil, or other material on the islands; 3) Loss of shallow water nearshore habitat utilized by resident or migratory fish such as striped bass and winter-run chinook salmon; and 4) The potential adverse impacts to Special Status Species, such as the loss of black rail habitat or Mason's *lilaeopsis* plants when placing dredge spoil.

The best SRA habitat is found where relatively deep water and dry land meet at a steep gradient. This is not true in many areas of the Delta where going from higher to lower elevation, riparian vegetation is replaced by marsh vegetation dominated by tules and cattails, then mudflats, and finally deeper water. These areas are not suitable for creating SRA habitat unless the gradient could somehow be increased. Then bank protection is often required to stop the erosion that results from wave action.

#### **F. Planting Techniques**

Plant establishment requires adequate water. The level of the water table at interior island sites should be determined. Soil moisture can be controlled by the District to facilitate the growth of plants.



Figure 9. Alternative slope protection material - Armorflex®

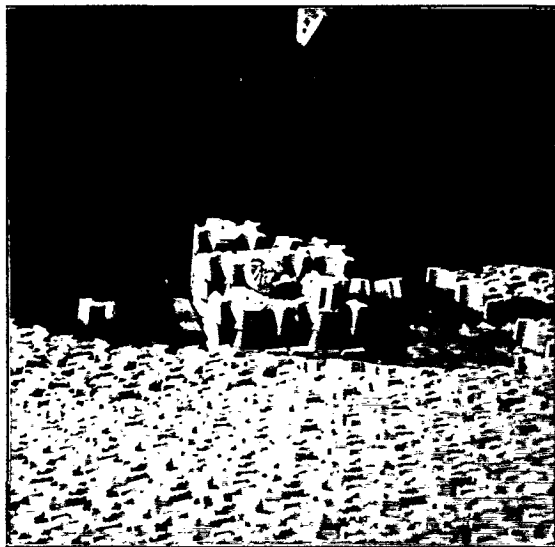
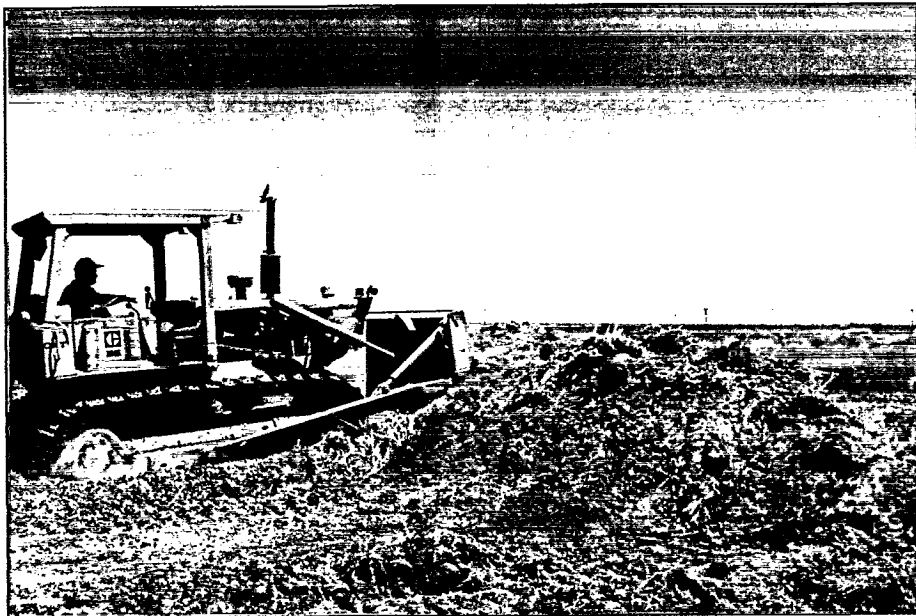


Figure 10. Alternative slope protection material - Trilock®



**Figure 11.** Conversion of agricultural land to wildlife habitat.

The easiest and least expensive method for improving water-land interface areas in the Delta may very well be to simply plant certain species of trees at the waterside toe of existing riprapped levees. Table 1 is a list of the common trees and shrub species native to the Delta.

Table 1. Common Trees and Shrubs Native to the Delta<sup>1</sup>

COMMON NAME	SCIENTIFIC NAME	DESCRIPTION
American dogwood	<i>Cornus sericea</i>	Shrub
Arroyo willow	<i>Salix lasiolepis</i>	Shrub/small tree
Shining willow, Yellow willow <sup>2</sup>	<i>Salix lucida</i>	Large shrub/tree
White alder <sup>2</sup>	<i>Alnus rhombifolia</i>	Tree
California button bush <sup>2</sup>	<i>Cephalanthus occidentalis</i>	Shrub/small tree
Red willow <sup>2</sup>	<i>Salix laevigata</i>	Tree
Goodding's black willow <sup>2</sup>	<i>Salix gooddingii</i>	Tree
Box elder <sup>2</sup>	<i>Acer negundo</i>	Tree
Oregon ash <sup>2</sup>	<i>Fraxinus latifolia</i>	Tree
Sandbar willow	<i>Salix exigua</i>	Shrub/small tree
California rose	<i>Rosa californica</i>	Shrub
Fremont cottonwood	<i>Populus fremontii</i>	Tree
California wild grape	<i>Vitis californica</i>	Vine/shrub
Blue elderberry	<i>Sambucus mexicana</i>	Shrub
California black walnut	<i>Juglans californica</i>	Tree
Western sycamore	<i>Platanus racemosa</i>	Tree
Oaks	<i>Quercus</i> spp.	Tree

<sup>1</sup> Plants, in general, have been arranged according to elevation. Dogwoods, willows, etc., are 2-3 feet above mean sea level or ground water, willows and cottonwoods above 3 feet, and sycamores and oaks above 6 feet.

<sup>2</sup> Common trees or shrubs best suited for levees. These species would create SRA habitat and should pose fewer problems to those responsible for maintaining levee stability.

Certain tree and shrub species survive best when planted in the late fall/winter period. Irrigation may not be needed during the following summer if roots have reached the water table. Careful planning may eliminate the need for irrigation systems.

Tree mats, or weed cloths, can be used around plants to control weeds and slow moisture loss. Plastic tubes or wire mesh can be placed around plantings to protect them from rodent damage.

Willow cuttings do best when planted directly into moist ground from late fall through April. They may be planted later with the following conditions in mind:

1. The cuttings should be at least three feet in length and placed two feet or so into the ground. Deeper is preferable, depending on water table depths. Removing leaves from cuttings prior to planting will help prevent their drying out.

2. Irrigation may be required for plantings. This may be avoided if the plants are placed such that the roots extend into the soil below the water table. Berms or fills along levees are excellent areas.
3. Fewer shoots will survive when they are planted during the warm, growing season. Therefore, more should be planted to make up for lower survival.

Cottonwoods and button willows can also be started this way. They are not as hardy as willows and more will die. Rooting them in pots prior to planting may yield better results. Small diameter cuttings (no bigger than one inch) work better than larger ones. The wood in larger cuttings will often rot, resulting in death after a year or so.

Willow wattling is a method which involves the placement of bundles of willow cuttings in trenches. This method is often used on steep wet slopes because the bundles of willows help control erosion, even before the trees sprout and begin to grow.

Use transplants or nursery stock for other trees whenever possible. Two years of lead time may be needed for nursery stock.

Elderberry plants shall be transplanted according to the USFWS handout entitled "General Compensation Guidelines for the Valley Elderberry Longhorn Beetle" (February 26, 1993).

Plant native species wherever practicable (Table 1). The planting plan should also list specific ground cover treatments of forbs and grasses. Site conditions should always be considered when selecting plants. For instance, trees subject to windthrow should obviously be avoided on standard levees. Non-native trees and shrubs should be replaced with native species.

#### **G. Mitigation Plans**

SB 34 requires each Reclamation District to prepare a mitigation plan for review by the DFG if there are adverse impacts. In most cases the plans will be prepared by a biologist(s) hired by the District. The mitigation plan does not discuss legally binding agreements or other elements that are to be found in the Mitigation Agreement.

Mitigation plans should try to minimize development and long term maintenance costs. The planting of trees which will effectively "shade out" understory vegetation over time may reduce vegetation control expenses. Any proposed open water areas should be designed so that long term pumping and dredging costs are minimized.

Each mitigation plan must contain the following parts:



1. The reason for mitigation and the place where the adverse impact occurred. This should include the acreage of each habitat type that was removed or changed, and the process [e.g. the Habitat Evaluation Procedure (HEP)] used to determine the size and type of the mitigation area. Alternatives to the HEP process, such as the use of simple ratios comparing habitat lost to habitat recreated, may be acceptable. This should be discussed considering the regrowth time for the habitat, species to be benefitted, and other factors.
2. Map with the following or similar scale: one inch = 1,000 feet. The map should show the specific place proposed for mitigation, the proposed design, and planting plans for vegetation at the site.
3. A list of plant species to be planted and a map of the proposed planting locations. A planting protocol should describe the specific number of trees and shrubs that will be planted. The number of these shrubs initially planted should take into account a preliminary estimate of planting mortality anticipated in the first five years after planting.
4. Schedule for completion of planting and monitoring. The detailed monitoring plan should describe the habitat components that will be monitored, how they will be measured, the monitoring frequency, who will perform the monitoring, and interim and long-term remedial actions should the predetermined success criteria (80% survival) not be achieved.
5. Discussion of present and proposed land uses on the mitigation land and nearby lands, including sport or fee hunting, hiking trails, etc.
6. Provisions for protection or restoration of special status species, if applicable.
7. List of references.
8. Itemized costs for the proposed mitigation. We will work with the districts to minimize the amount of money needed for mitigation. There is a limited amount of funding available to fully reimburse mitigation costs.

## V. MITIGATION BANKS

The Resources Agency and the California Environmental Protection Agency have jointly developed an official policy on conservation banks (Appendix C).

Mitigation banks will be created after a consideration of levee maintenance activities which avoid, lessen or eliminate mitigation requirements. Banks are currently being developed at various locations in the Delta, as near as possible to the locations of adverse impacts. They are being used to offset past, present, and future net long-term losses to fish and wildlife habitat.

Banking develops mitigation before project impacts occur. Districts have the opportunity to develop habitat in a mitigation bank. Each District, even with a workplan that does not specify exact work locations, will be eligible to receive funding for the current year. This will occur if the quality and quantity of habitat in the mitigation banks equals or exceeds that which could be removed that year as a result of levee maintenance. This will greatly facilitate the funding application approval process. However, the DFG will continue to review specific workplans as required to determine whether a potential for long-term loss of habitat exists.

Mitigation banks can be developed to provide for complete mitigation of anticipated impacts, exclusive of impacts to threatened and endangered species. In this scenario, DFG assumes that all of the habitat along a section of levee will be removed as a function of the proposed maintenance activities, either in current or future years. This scenario allows the Districts the opportunity to mitigate for all expected habitat losses at one time, thereby allowing construction and maintenance activities to proceed without the necessity for site-by-site mitigation negotiation.

Mitigation banking offers the Districts the option of comprehensive mitigation planning over the life of the project. For many Districts and agency representatives, as well as DFG and DWR personnel, it is a significant financial and administrative burden for the Districts to prepare individual mitigation plans for each work site on an annual basis.

Mitigation banking offers several advantages over past mitigation policies in the SB 34 program:

1. Significant funds may be saved by developing larger areas of mitigation lands rather than small, isolated pieces that are difficult to manage and monitor. Site-by-site, year-by-year mitigation planning is costly and time consuming.
2. Based on reasonable estimates of program impacts, mitigation banks may be planned and cost estimates developed before the levee work occurs, thereby facilitating funding application approval. Currently, the Districts prepare annual

projections of expected work activities and then must develop a mitigation plan for each site, before annual funding application approval.

3. Once the cost of program mitigation is approximated, funds may be set aside specifically for mitigation implementation. Once programmatic mitigation has been satisfied, levee projects could proceed on an annual basis with the knowledge that the no "net long-term loss of habitat" mandate has been met in advance.

## **VI. PROCEDURES AND LAWS**

### **A. Habitat Assessment Criteria**

A habitat assessment is required before levee repairs are undertaken. This provides a basis for determining impacts to special status species and fish and wildlife habitats. Assessments must be prepared by a qualified biologist according to SB 34 procedures. The potential for the avoidance of impacts will be thoroughly examined.

### **B. Workplan Submission**

The levee maintenance workplans should specify proposed work locations for the current fiscal year. This provides a basis for project avoidance and mitigation.

### **C. California Environmental Quality Act (CEQA) Compliance**

Before submitting annual funding applications, each District must determine compliance with CEQA. Each Reclamation District is a lead agency under CEQA, and should consult the relevant sections of State CEQA Guidelines to determine their obligations.

The following sections of CEQA should be reviewed for applicability:

1. Section 15300.2(c) of the CEQA guidelines specifies that "A categorical exemption shall not be used for an activity where there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances."
2. Section 15301(c) of the Guidelines states that a Class 1 Categorical exemption shall exist for projects except "where the activity will involve removal of a scenic resource including a stand of trees . . ."
3. Section 15065 of the CEQA Guidelines specifies that "an EIR for a project will be required if ... The project has the potential to ... reduce or restrict the range of a rare or endangered plant or animal..." (see discussion in "Endangered Species" section). A Negative Declaration can be prepared if it is shown that, through mitigation, significant impacts to special status species are avoided.

The DFG is a Trustee Agency for levee maintenance projects under CEQA. As such, it must respond to consultation by the Lead Agency in order to assist the Lead Agency in preparing adequate environmental documents for the project.

#### D. Permits and Agreements

Districts should consult with "responsible" public agencies to determine permit requirements. Costly project delays and changes will be reduced. For in-channel and waterside work, the following permits may be needed:

1. U.S. Army Corps of Engineers (COE) Permit

A pre-application meeting between the applicant and other reviewing agencies might help to determine the need for a COE permit. Call the Sacramento office of the COE at (916) 557-5250 for information. A meeting can be scheduled and may resolve agency concerns before you submit an application. Concerns may include whether State or Federal Endangered Species consultation is required and what project modifications might eliminate a consultation requirement. This can greatly speed up the project approval process.

2. State Lands Commission (SLC) Permit

The SLC has the authority to lease or otherwise encumber tidelands and submerged lands of the State, including the beds of navigable rivers, sloughs, lakes, etc. and has jurisdiction from mean high water and waterward, including the bottoms of Delta channels. Most levee maintenance or mitigation projects in the Delta which involve dredging or bank modifications below the ordinary high water mark of tidal waterways will require a SLC leasing agreement or a dredging permit. An example of a project under SLC jurisdiction would be dredging to acquire fill material for bank stabilization for SRA habitat development.

The SLC is automatically notified of projects when a COE permit is required. However, a determination of whether a SLC permit or leasing agreement is required can be made by writing a letter to the SLC requesting a status determination. This will not require a fee. In many cases, SLC does not have jurisdiction and work can proceed without delay. If the issue of whether a leasing agreement is unresolved, the SLC will normally assume that an agreement will be required. Master leases may be available which are one-time applications and will cover the bulk of the District's maintenance practices.

When a SLC permit or agreement is required, processing time will normally take around six months. Dredging permits and leasing agreements are brought before the SLC for review. The Commission meets at irregular intervals. A timely determination of the need for permits, and an early scheduling of projects on the SLC agenda, can help avoid costly project delays.

All of the necessary requirements for a SLC permit are in the general information and application form available at the Sacramento office. Questions should be directed to:

State Lands Commission  
Land Management Division, Delta Unit  
100 Howe Ave.  
Sacramento, CA 95825  
(916) 574-1900

3. 1601 Agreement

An agreement under Fish and Game Code Section 1600 et. seq. will be required for any work to be conducted waterward from the waterside crown of the levee. This will include levee maintenance work and projects involving dredging.

The conditions of one 1601 agreement may be applicable at more than one geographical location and be applicable for projects that last more than one year. Many types of levee maintenance activities, including repairing of minor slipouts and shoreline erosion up to 100 lineal feet in length, can occur under the authority of a Routine Maintenance Agreement from the Department. These agreements have been prepared for most of the Reclamation Districts in the Delta and will not require a separate notification to the Department for each individual levee maintenance activity. For policies and specific project information regarding 1601 agreements, contact the Department's Delta Levees Project at (916) 355-0271.

4. National Pollutant Discharge Elimination System (NPDES) Permits

The Central Valley Regional Water Quality Control Board (CVRWQCB) has jurisdiction over projects that could discharge pollutants into any surface waters of the State. The discharges include release of channel bottom sediments into the water column as a result of dredging. The CVRWQCB becomes aware of projects through either the COE permit or CEQA review process.

For additional information regarding the requirements for a permit, contact them at (916) 445-0270.

5. Fish Screening

Fish screening policies and criteria are being developed pursuant to Fish and Game Code Sections 5980 et seq., 6020 et seq. and 6100 et seq.

## **E. Special Status Species**

### **1. Management Authorizations for State Listed and Candidate Species**

The California Endangered Species Act (CESA), Sections 2080 and 2085 of the Fish and Game Code, prohibits the "take" of any State listed Endangered, Threatened, or Candidate species. "Take" includes not only direct mortality but other actions that may result in adverse impacts (injury) to individuals of a listed species. Pursuant to Section 2081, the DFG may issue authorizations to "take" listed species for management purposes. Districts may apply for a Section 2081 Management Authorization (MA) through the DFG Regional office. Districts are responsible for completion of appropriate environmental documents pursuant to CEQA, as well as results of any surveys and biological assessments. A Categorical Exemption under CEQA for projects involving the potential take of listed or candidate species is not acceptable and requires a Mandatory Finding of Significance under CEQA.

For projects which may affect a special status species, informal consultation may be all that is required. This consultation takes place early in the project approval process when the project is first proposed. A clear project description with detailed maps of the site in a scale sufficient to accurately determine the potential impacts must be sent to the DFG, Region, Delta Levees Project. A field trip may be warranted to assess the site. The DFG person assigned to the project will consult with the most knowledgeable personnel within or outside the Department. If avoidance techniques can be developed and agreed upon by all parties, or if it is clearly demonstrated that the project cannot affect any special status species, the project can continue with no further action regarding State listed species. These consultations are finalized in a 1601 Streambed Alteration Agreement, CEQA document, or other enforceable mitigation document.

A Fish and Game Code (Section 2081) Management Authorization (MA) is a legally enforceable document developed by the DFG, using information from all sources, including the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS). A Management Authorization incorporates species management activities and mitigation measures into the project design. These measures must demonstrate a benefit to the species that more than offsets the taking. The applicant must sign a CESA Memorandum of Understanding to carry out these activities for the benefit of the affected species. A copy of the current guidelines for Section 2081 MA's can be obtained by contacting the DFG at (916) 355-7030.

### **2. Federal Consultation**

Formal consultation under Section 7 of the Federal Endangered Species Act is required for all projects which may involve adverse impacts to Federally listed Threatened or Endangered species, if there is federal involvement in the project. Federal involvement occurs when federal money is used for the project or when there are federal permits required as part of the project (e.g., COE permit).

If there is a COE permit required as part of the project, consultation will be undertaken by the COE during permit review. Reclamation Districts shall notify the District Engineer at the COE if any Federally listed (or proposed for listing) Endangered or Threatened species or critical habitat might be affected, or is in the vicinity of the project. The COE will consult with the USFWS or NMFS to determine if any actions which they authorize will jeopardize any Threatened or Endangered species or its critical habitat. An example is the removal of the host plant for the Valley Elderberry Longhorn beetle, which is found in many parts of the Delta. The COE will initiate Section 7 consultation with the USFWS which will issue a jeopardy or no-jeopardy biological opinion. A no-jeopardy opinion will lead to either the issuance of an NWP or an Individual Permit.

If there is no federal involvement and the project has the potential for affecting a federally listed species, the District must contact the USFWS and/or the NMFS to determine if a Section 10A Incidental Take Permit and Habitat Conservation Plan will be required. The DFG will coordinate with the USFWS, NMFS, and the District to develop satisfactory take avoidance alternatives, mitigation measures, and habitat enhancements that can be incorporated into the State and federal documents for the project.

Guidance for federally listed species of the Delta include "General Compensation Guidelines for the Valley Elderberry Longhorn Beetle" (USFWS, February 26, 1993).

### 3. State Consultation

The California Endangered Species Act (CESA), Section 2090 of the Fish and Game Code, states that each State lead agency shall consult with the Department of Fish and Game (Department) to ensure that any action authorized, funded, or carried out by that State lead agency is not likely to jeopardize the continued existence of any endangered or threatened species.

Generally, Reclamation Districts themselves are not considered State lead agencies. However, Reclamation Districts are considered a State lead agency under certain circumstances and are expected to consult with the Department pursuant to CESA, Section 2090.



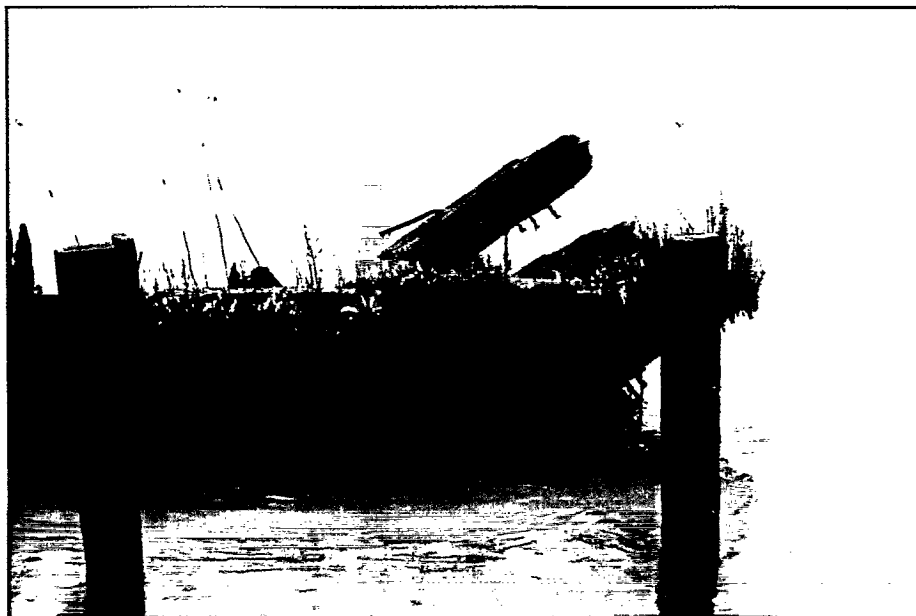
The Department must issue a written finding (biological opinion) to the State lead agency based on its determination of whether a proposed project would jeopardize a listed species or result in the destruction or adverse modification of habitat essential to the continued existence of the species. The written finding must also state whether a proposed project would result in any taking of listed species incidental to the proposed project. If jeopardy is found then the Department must specify alternatives consistent with conserving the species and which would prevent jeopardy (Section 2091 Fish and Game Code). If taking incidental to the project is found, the Department must specify appropriate measures to minimize the adverse impacts of incidental taking.

Consistent with CESA, and as discussed in this document, the first priority is to avoid adverse impacts to any listed species or their critical habitat. The "timing" of activity may be important in some areas to avoid impacts on nesting species or migratory fishes. In some cases, such as with the presence of listed plant species, avoidance is not feasible. In these cases, measures to minimize adverse effects must be implemented. These types of specifics are included in the biological opinion.

Personnel in DFG's SB 34 program have available several guidance documents which have been developed for various listed species (e.g., Swainson's hawk, Delta smelt, winter-run chinook salmon). Copies may be obtained from DFG SB 34 staff. While no mitigation has yet been proposed or initiated for the Mason's lilaeopsis, future mitigation using a variety of structures and man-made substrates might be worth pursuing (Figure 11).

SB 34 staff have available a list of all Special Status species known to occur in the Sacramento-San Joaquin Delta (Appendix D), as well as a list of DFG's "species of special concern".

Questions regarding consultation for federally listed species should be directed to personnel at the Sacramento U.S. Fish and Wildlife Service office a (916) 978-4866 and/or the National Marine Fisheries Service (NMFS) at (707) 578-7513. For State listed species contact SB 34 staff at (916) 355-0271, or write: Department of Fish and Game, Delta Levees Project, 1701 Nimbus Road, Rancho Cordova, CA 95670.



**Figure 12.** Potential habitat modification techniques for Mason's lilaeopsis.

## VII. MITIGATION AGREEMENTS

The interagency MOU requires each District to enter into a legally enforceable mitigation agreement with the DFG for all mitigation. Necessary elements of mitigation agreements may include:

1. Securing the Parcel--The Districts must provide permanent restrictions over mitigation lands. The restriction is normally a conservation easement. The easement may go to another party besides the Department, such as the Nature Conservancy. Perpetual maintenance is required.
2. List of Estimated Costs--This includes the following:
  - a. Costs for acquiring fee title or a permanent conservation easement
  - b. Development costs for land (these include the costs of development of water sources, screening, etc.)
3. Security deposit or other arrangement to cover default
4. Consistency with levee maintenance activities--The finalized agreements may allow the Districts to receive mitigation credit for vegetation which is allowed to redevelop on the levees within the constraints described in the Vegetation Management Guidelines for HMP compliance.
5. Mitigation Plan--A plan for constructing, planting (including assuring performance), and monitoring the mitigation area
6. Each District will be given the option of either providing mitigation on the interior of the District's own island or tract or elsewhere in a mitigation bank. Under the latter option, the mitigation would occur as close as possible to the point of impact, while maintaining the habitat values associated with large banks.

# **VIII. EXEMPTION FOR EMERGENCY**

Emergency situations will be resolved based on current definitions. Normally, an emergency is declared by the district, the county, and the state. Follow-up work is normally required.

## IX. HABITAT TYPES

The vegetation associated with the levees in the Delta can be categorized into six plant associations which are described below. Losses of all types, except ruderal, are subject to mitigation requirements through the SB 34 program.

1. Riverine Aquatic Bed (RAB) -- The riverine aquatic bed is present on the waterside toe of the levee. This plant community consists of submerged, floating-leaved plants growing where the streambed is up to one meter (3 feet) or so in depth. Typical plant species found in this zone include elodea (*Elodea canadensis*), hornwort (*Ceratophyllum demersum*), and milfoil (*Myriophyllum* spp.).
2. Freshwater Marsh (FM) -- Freshwater marsh habitat along the levees consists of both tidal or nontidal freshwater marshes.
  - a. The tidal freshwater marsh community is present on the waterside toe of the levee and typically occurs in the slowest moving waters where tules (*Scirpus* spp.) have become established. On higher elevated berms, willows (*Salix* spp.), buttonbush (*Cephalanthus occidentalis* var. *californicus*), and American dogwood (*Cornus sericea* ssp. *sericea*) are characteristic plants.
  - b. Freshwater nontidal marshes are behind levees where there are seeps or tow ditches. This plant community typically includes cattails (*Typha* spp.), common reed (*Phragmites australis*), tules, barnyard grass (*Echinochloa crus-galli*), and nutgrass (*Cyperus* spp.). Willows and other shrubs such as dogwood and buttonbush may become established on the higher margins of this marsh as well.
3. Ruderal (R) -- This vegetation association consists of plants that are frequently and seriously disturbed and where grasses and herbaceous plants predominate. Representative species include blackberries (*Rubus* spp.), fennel (*Foeniculum vulgare*), mugwort (*Artemisia douglasiana*), yellow star thistle (*Centaurea solstitialis*), prickly lettuce (*Lactuca serriola*), gum plant (*Grindelia camporum*), mustard (*Hirschfeldia incana*), wild radish (*Raphanus sativus*), stinging nettle (*Urtica dioica* ssp. *holosericea*), giant reed (*Arundo donax*), common reed, Johnson grass (*Sorghum halepense*), and wild oats (*Avena* spp.).
4. Scrub-Shrub (SS) -- Scrub-shrub habitat includes areas dominated by young trees, shrubs, and vines predominantly less than 6 meters (20 feet) tall. The dominant species making up the scrub-shrub habitat include willows, buttonbush, young alders (*Alnus rhombifolia*), wild rose (*Rosa californica*), elderberries (*Sambucus mexicana*), dogwood, coyote brush (*Baccharis pilularis*), and wild grape (*Vitis*

*californica*). Herbaceous plants such as sedge (*Carex* spp.), stinging nettle, common reed, and mugwort are often intermixed within the scrub-shrub.

5. Riparian Forest (RF) -- The riparian forest habitat is characterized by woody vegetation greater than 6 meters (20 feet) tall, often with a dense, shrubby understory. Cottonwood (*Populus fremontii* ssp. *fremontii*), sycamore (*Platanus racemosa*), alder, box elder (*Acer negundo*), valley oak (*Quercus lobata*), and willows are common trees, and blackberries, buttonbush, wild rose, wild grape, and mugwort are typical of the understory. Cultivated and introduced trees such as eucalyptus (*Eucalyptus* spp.), conifers, and English walnut (*Juglans regia*) may fall into this category as well.
6. Shaded Riverine Aquatic (SRA) -- The shaded riverine aquatic habitat is created when vegetation from the scrub-shrub and riparian forest habitat extends over and shades the aquatic environment. The plants' overhanging branches, exposed roots, and downed vegetation contribute to its value. The dominant species making up the shaded riverine aquatic environment in the Delta include willows, alder, cottonwood, and box elder. Plants with limited overhanging and protruding leaves, branches, or roots, such as tules, blackberries, or dogwood, are not included as SRA vegetation for the purposes of impact assessments.

The Cowardin classification system (using the nomenclature of the COE, Sacramento-San Joaquin Atlas, 1979) is an alternative to which habitat types are categorized. The Cowardin system uses classifications such as palustrine emergent, palustrine forested, etc., but it does not, however, include references specific to SRA habitat which are needed for discussion purposes.

**APPENDIX A**

**MEMORANDUM OF UNDERSTANDING**



## MEMORANDUM OF UNDERSTANDING

The 1992 Memorandum of Understanding between the California Department of Water Resources, Department of Fish and Game, The Reclamation Board, and the Resources Agency was enacted to implement the no net long-term loss of habitat policy that is mandated in the Delta Flood Protection Act of 1988 (SB 34). The section regarding mitigation states:

The mitigation element shall consider the value of the riparian and fisheries habitat and the need to provide flood protection based on sound engineering.

The mitigation element shall include provision for the protection of fish and wildlife habitat determined to be necessary and not injurious to the integrity of flood control works.

The mitigation element shall provide for the full mitigation of channel islands or berms with significant riparian communities if proposed for use as borrow sites for levee repair materials.

The mitigation element shall ensure that the project does not result in a net long-term loss of riparian, fisheries, or wildlife habitat.

The mitigation element shall consider the mitigation to be accomplished, if any, under the California Environmental Quality Act, the California Endangered Species Act, and Section 1600 et seq. of the California Fish and Game Code.

The mitigation element shall provide an implementation plan which shall do the following:

Describes the mitigation work to be implemented.

Includes a schedule for implementation of the mitigation work which ensures that mitigation work will be accomplished prior to, or concurrent with, the construction of the project, or a written description why doing so would be impractical, which includes a schedule detailing when mitigation would be implemented as soon thereafter as practical.

Includes a financing plan for the mitigation work, the share of mitigation costs attributable to each source, and a schedule of when funds are to be provided.



**APPENDIX B**

**VEGETATION MANAGEMENT GUIDELINES  
FOR LOCAL, NON-PROJECT DELTA LEVEES**



Vegetation Management Guidelines  
for Local, Non-project Delta Levees

I. PURPOSE

- A. To provide Delta reclamation and levee districts with guidance for levee vegetation management in accordance with the State's Sacramento-San Joaquin Delta Flood Hazard Mitigation Plan, August 21, 1983 (HMP). Specifically, to clarify HMP maintenance item B.2.i. (page 12):

"Cutting, removing, or trimming vegetation such as weeds, brush, and trees to the extent necessary to maintain a safe levee."

- B. To assist the districts who, as a part of their flood hazard mitigation activities, must demonstrate avoidance of habitat impacts in compliance with DFG's Streambed Alteration Agreements, CEQA, NEPA, State and federal endangered species acts, etc.
- C. To encourage districts to modify their vegetation maintenance practices, as per the guidelines, where possible, to avoid or minimize the adverse impact on fish and wildlife habitat, or when impact is unavoidable, to allow reasonable on-site regrowth of vegetation while maintaining the safety and inspectability of levees.
- D. To modify the format of DWR levee inspection reports to be consistent with guidelines described in this document.
- E. To insure that the State's HMP responsibilities are met to provide protection from flooding by maintaining local, non-project Delta levees in an environmentally sensitive manner.

II. GUIDELINES

- A. **Waterside Slope of Levee:** All vegetation except grasses must be cleared from the top five feet of the waterside slope of the levee. Native grasses are encouraged in this area. Naturally growing vegetation below the cleared area should be pruned or removed only to the extent necessary to insure levee safety and inspectability. Large trees with extensive root systems are discouraged.
- B. **Landside of Levee:** Vegetation must be cleared from the entire landside slope of the levee and from a ten-foot

wide strip along the levee toe with the following exceptions:

- Existing, individual, mature trees may be retained provided they are spaced to ensure inspectability from the levee crown, and their limbs are trimmed up five feet from the ground.
- Grasses, preferably native, are encouraged to prevent erosion and allow clear inspection.

See attached Figure 1 for an illustration of this concept.

### III. ACTIONS

- A. Districts may revise their levee vegetation management practices in accordance with guidelines described in this document. Vegetation management may not be limited to the above guidelines. The district engineer will make recommendations to district for vegetation removal or retention based on a balance between avoiding and/or minimizing fish and wildlife habitat impacts resulting from levee work and the need to maintain the safety and inspectability of the levee structure.
- B. DWR levee inspectors, the district representative and the district engineer will jointly perform onsite annual inspections of non-project levees and prepare inspection reports. Inspection reports will document the presence of levee vegetation in accordance with the above guidelines. Vegetation on levees maintained in accordance with the guidelines will be in compliance with HMP. DWR levee inspectors will furnish the inspection report to the district engineer.

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I concur that the above "Vegetation Management Guidelines for Local, Nonproject Delta Levees" are in accordance with the State of California's Sacramento-San Joaquin Delta Flood Hazard Mitigation Plan.

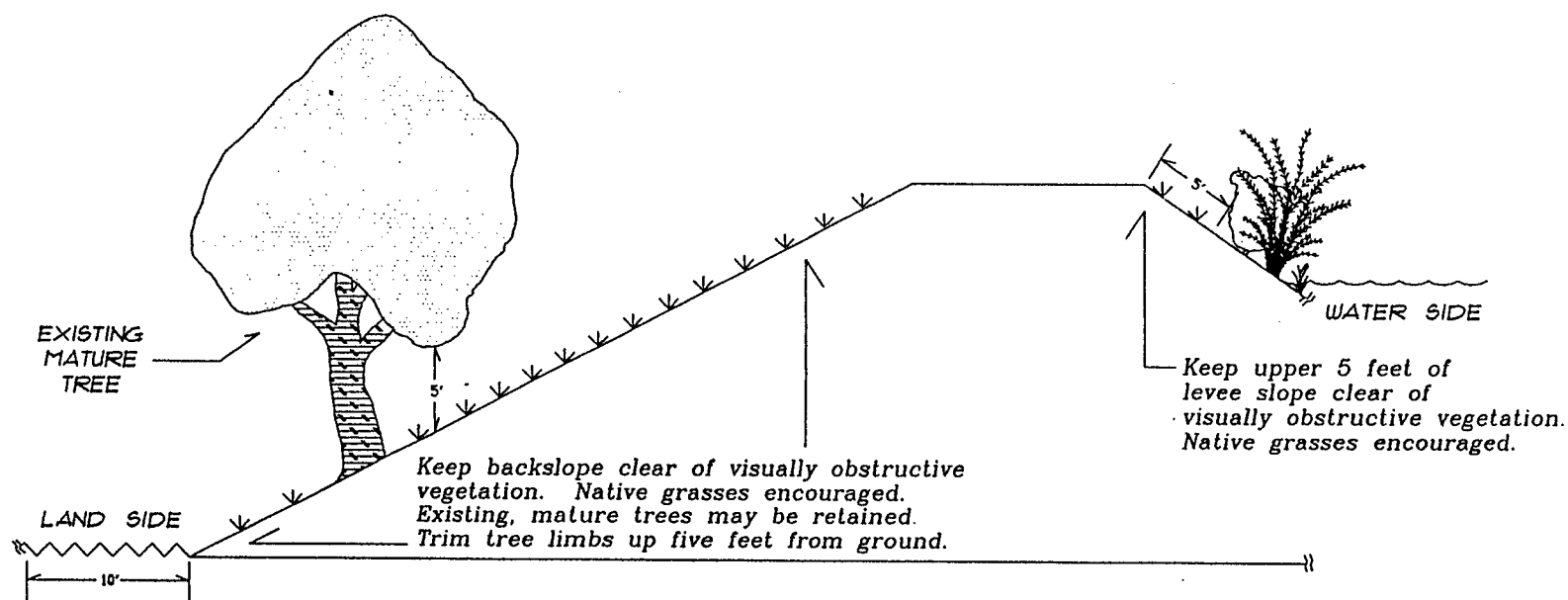
  
\_\_\_\_\_  
State of California  
Office of Emergency Services

Date 4/15/84

  
\_\_\_\_\_  
Federal Emergency Management  
Agency

Date 4-22-84

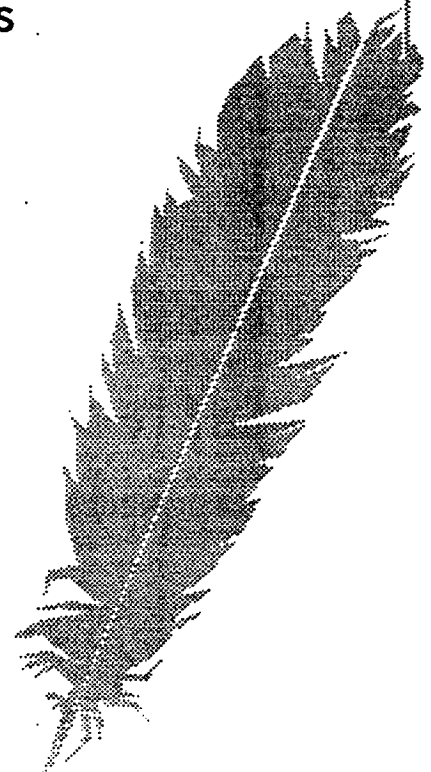
FIGURE 1  
Vegetation Management Guidelines  
for Local, Nonproject Delta Levees



Based on critical elevations for natural vegetation establishment presented in the Corps of Engineers' study "Design and Biological Monitoring of Wetland and Riparian Habitats Created with Dredged Materials, Final Report - Deep Water Ship Channel Monitoring Program", September 1990.

**APPENDIX C**

**OFFICIAL POLICY  
ON CONSERVATION BANKS**



**California Environmental  
Protection Agency**

555 Capitol Mall, Suite 235  
Sacramento, CA 95814  
PHONE (916) 445-3846  
FAX (916) 445-6401



PETE WILSON  
GOVERNOR

**The Resources  
Agency**

1416 Ninth Street, Suite 1311  
Sacramento, CA 95814  
PHONE (916) 653-5656  
FAX (916) 653-8102

TO: All Departments, Commissions, Boards and Conservancies  
("Departments")

FROM: Douglas P. Wheeler  
The Resources Agency

James M. Strock  
California Environmental Protection Agency

Handwritten signatures of Douglas P. Wheeler and James M. Strock.

DATE: April 7, 1995

SUBJ: Official Policy on Conservation Banks

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The executive and legislative branches have endorsed the use of conservation banks as a means to accomplish important resource management goals. This document provides formal policy guidance on how to achieve this directive.

**INTRODUCTION**

A conservation bank is a single parcel, or a series of contiguous or non-contiguous parcels, of habitat which is managed for its natural resource values. The resource benefits derived from this management regime are sold as "credits" to project proponents who seek mitigation opportunities to compensate for

resource impacts elsewhere. Credits may be generated to meet any number of resource conservation needs, including compensation for impacts to wetlands, threatened or endangered species, Environmentally Sensitive Habitat Areas, mudflats, sub-tidal areas, and less sensitive resources.

Conservation banks, if properly established and managed, serve several useful functions. First and foremost, banks provide for the conservation of important habitats and/or habitat linkages.

Second, they provide a viable alternative to the current practice of requiring piecemeal mitigation for individual project impacts. Individualized mitigation projects which have little connection with their surrounding ecosystem are often much more prone to failure than a mitigation project which is incorporated into a larger, ecosystem-based conservation bank or regional conservation plan.

Third, conservation banks can take advantage of economies of scale that are often not available to individualized mitigation projects.

Fourth, conservation banks provide significant incentives for private landowner participation and represent one of the best examples of private/public partnerships in an era of shrinking budget resources.

Fifth, conservation banks can be a major funding component for the creation of an ecosystem preserve under a regional conservation plan.

Sixth, and finally, conservation banks simplify the regulatory compliance process while achieving greater conservation goals.

### CONSERVATION BANKING

For purposes of providing guidance on conservation banking, all Departments shall designate and train personnel to actively work with potential bank developers in accordance with the following precepts:

1. The priority for mitigation should be to accomplish it at a site which provides for the long-term conservation of habitat and species. As such, off-site mitigation is specifically sanctioned in the context of an otherwise permissible conservation bank.

2. A bank may be established pursuant to regulatory permit or contract between the bank developer and the appropriate regulatory agency(s). Where a bank is established pursuant to contract, care must be taken to create a legally enforceable instrument.



3. There is no minimum or maximum size of a conservation bank and it may be divided into clearly defined subareas. However, the bank and each of its subareas (if any) should be large enough to be ecologically self-sustaining or part of a larger conservation strategy that has a reasonable expectation of being accomplished.

4. Upon sale of the first credit in the bank or subarea, the land in the bank or subarea must be permanently protected through fee title or conservation easement. The land-use restrictions should run with the land and be recorded in the appropriate county(s) of jurisdiction.

5. Before selling bank credits, a proposed conservation bank should be approved by the appropriate resource management agency(s). Basic elements in any approvable bank proposal should include, but are not limited to:

- a. identification of a bank manager;
- b. identification of the geographical boundaries of the bank and the service area of the bank;
- c. provision for fundamental property protection measures (e.g., fencing some or all of the bank property if deemed appropriate,

control of off-road vehicle use, etc.);

d. provisions for the resolution of current or prospective land use conflicts involving the bank lands (e.g., rights-of-way issues, existing use issues, adjacent land-use issues);

e. provisions requiring an annual report by the bank manager to be submitted to the appropriate regulatory agency(s).

6. Prior to the sale of credits, a resource management plan should be approved by the appropriate regulatory agency(s). A sufficient level of funding with acceptable guarantees (e.g., cash, letters of credit, public charity, public funding mechanism) should be provided to fully ensure the operation and maintenance of the bank as may be required.

7. Provision should be made for long term management of bank lands after all the mitigation credits have been awarded. Generally, land management responsibilities should ultimately vest in a resource management agency or qualified non-profit organization, although a private entity may be an acceptable long-term manager.

8. Provision should be made for ensuring implementation of the resource

management plan in event of non-performance by the bank owner and/or operator.

9. Provisions should be made in any bank establishment for the monitoring and reporting of identified species/habitat management objectives.

10. An easement or other agreement should be established at the bank in favor of appropriate resource management agency(s) guaranteeing the agency's right of entry onto bank lands for the following purposes:

- a. Inspections;
- b. Specified resource management responsibilities;
- c. Quality Assurance/Quality Control review with regard to bank management and operation;
- d. Resource management should the bank operator fail to implement prescribed resource management responsibilities.

11. Bank credits should be established by reference to an environmental baseline which may, but need not be, assessed at the time of the bank creation. This baseline will be used to establish credits for a number of categories requiring

resource management, including, but not limited to, the following:

- a. Resource Preservation (the preservation of specified resources through acquisition or other appropriate means);
- b. Resource Enhancement (the enhancement of a degraded resource);
- c. Resource Restoration (the restoration of a resource to its historical condition);
- d. Resource Creation (the creation of a specified resource condition where none existed before).

12. The award of bank credits should be negotiated on a case-by-case basis between the project proponent in need of the subject credits, the regulatory agency(s) of jurisdiction, and the bank manager. Generally:

- a. Credits may be negotiated for available or prospective resource value establishment.
- b. Credits may be based on habitat acreage, habitat quality,

contribution to a regional conservation strategy that has been approved by the appropriate regulatory agency(s), or any other basis acceptable to the regulatory agency(s).

- c. Actual awards of bank credits need not be withheld pending full realization of the targeted resource value at the bank. Credit availability may vary in accordance with agreed upon performance criteria for the development of the resource value in question.
- d. Awarded bank credits, subject to the approval of the regulatory agency(s), should be made transferrable.

13. Whether out-of-kind mitigation credit will be allowed at a particular bank will require a fact-specific inquiry on a case-by-case basis for the project creating the impacts.

14. The creation of any conservation bank should be listed with the Resources Agency in accordance with forthcoming guidance for purposes of maintaining a statewide bank inventory.

## CONCLUSION

Conservation bank agreements developed between the bank developer and the appropriate regulatory agency(s) in accordance with the preceding precepts shall be considered consistent with state policy regarding conservation banks, assuming no violation of federal and state laws. Training manuals on this subject are forthcoming.

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**APPENDIX D**

**SPECIAL STATUS SPECIES  
OF THE SACRAMENTO-SAN JOAQUIN DELTA**



APPENDIX D  
Special Status Species of the Sacramento-San Joaquin Delta

	COMMON NAME	SCIENTIFIC NAME	STATUS		
			USFWS	CDFG	CNPS
MAMMALS	Salt-marsh harvest mouse	<i>Reithrodontomys raviventris</i>	E	E	-
	San Joaquin kit fox	<i>Vulpes macrotis mutica</i>	E	T	-
BIRDS	Tricolored blackbird	<i>Agelaius tricolor</i>	C2	SC	-
	Aleutian Canada goose	<i>Branta canadensis leucopareia</i>	E	-	-
	Swainson's hawk	<i>Buteo swainsoni</i>	C3	T	-
	Greater sandhill crane	<i>Grus canadensis tabida</i>	-	T	-
	California black rail	<i>Laterallus jamaicensis coturniculus</i>	C2	T	-
	Western pond turtle	<i>Clemmys marmorata</i>	C2	SC	-
REPTILES	Giant garter snake	<i>Thamnophis gigas</i>	T	T	-
FISH	Delta smelt	<i>Hypomesus transpacificus</i>	T	T	-
	Winter-run chinook salmon	<i>Oncorhynchus tshawytscha</i>	E	E	-
	Sacramento splittail	<i>Pogonichthys macrolepidotus</i>	P(T)	SC	-
INSECTS	Antioch Dunes anthicid beetle	<i>Anthicus antiochensis</i>	C2	-	-
	Sacramento anthicid beetle	<i>Anthicus sacramento</i>	C2	-	-
	Valley elderberry longhorn beetle	<i>Desmocerus californicus dimorphus</i>	T	-	-
PLANTS	Suisun marsh aster	<i>Aster lentus</i>	C2	-	1B
	California hibiscus	<i>Hibiscus lasiocarpus</i>	-	-	2
	Delta tule pea	<i>Lathyrus jepsonii</i> var. <i>jepsonii</i>	C2	-	1B
	Mason's lilaeopsis	<i>Lilaeopsis masonii</i>	C2	R	1B
	Delta mudwort	<i>Limosella subulata</i>	-	-	2
	Antioch Dunes evening primrose	<i>Oenothera deltoides</i> ssp. <i>howellii</i>	E	E	1B
	Sanford's arrowhead	<i>Sagittaria sanfordii</i>	C2	-	1B
	Marsh skullcap	<i>Scutellaria galericulata</i>	-	-	2



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**Land Subsidence in Drained Histosols and Highly Organic Mineral Soils of California**

Stuart Rojstaczer and Steven J. Deverel

## Land Subsidence in Drained Histosols and Highly Organic Mineral Soils of California

Stuart Rojstaczer\* and Steven J. Deverel

### ABSTRACT

This study was conducted to determine historical trends in subsidence in the Sacramento–San Joaquin Delta and their environmental controls. Historical subsidence was determined by measuring soil surface elevation loss near electrical tower foundations and by evaluating survey data between 1922 and 1981. The data indicated that subsidence slowed with time. In the western Delta, average subsidence rates were  $2.3 \text{ cm yr}^{-1}$  from 1910 to 1988 and  $1.5 \text{ cm yr}^{-1}$  from 1952 to 1988. Spatially variability in subsidence was correlated with organic matter content of the soil ( $r^2 = 0.62$ ), which in turn was related to the depositional and drainage history of the Delta. Subsidence rates appeared to be independent of crops grown.

**A**GRICULTURAL DRAINAGE of Histosols is common throughout the world and often leads to significant soil subsidence (Stephens et al., 1984). This subsidence can be accelerated if crop residue is burned after the harvest for pest and weed control or nutrient augmentation. The environmental problems associated with soil subsidence are both small scale and large scale in extent. Soil subsidence can greatly increase the potential for agricultural lands to be subject to flooding and poor drainage. On a global scale, the soil organic matter lost by oxidation and combustion of C can significantly contribute to the amount of  $\text{CO}_2$  in the atmosphere (Armentano, 1980; Rojstaczer and Deverel, 1993). The Sacramento–San Joaquin Delta has long been known as an area undergoing soil subsidence (e.g., Weir, 1938). Average rates of soil subsidence in the region are among

the highest in the world (Stephens et al., 1984). While soil subsidence and its environmental influences have been examined in detail in the Florida Everglades, little work has been done on examining the amount and causes of temporal and spatial variability of subsidence in other regions.

Soil subsidence in the Delta has been documented by several other workers (Weir, 1938, 1950; Broadbent, 1960; Prokopovitch, 1985; Rojstaczer and Deverel, 1993). Much of this work has been concerned with quantifying rates of subsidence in the region. Some laboratory research has been performed on Delta soils which shows that oxidation rates are strongly controlled by temperature and weakly controlled by soil moisture content under unsaturated conditions. Little research, however, has examined the causes of variations in the rate of Delta subsidence over time and space. This study examined historical trends in subsidence in the Delta and their environmental controls. Spatially variable and time-averaged subsidence rates were estimated by measuring elevation loss at electrical transmission towers installed in 1910 and 1952 and leveling surveys done from 1922 to 1981. We examined the influence of agricultural practices on subsidence rates. We also examined the influence of sediment depositional environment and soil C content on subsidence.

### MATERIALS AND METHODS

#### Description Of Study Area

Figure 1 shows the location and geographic features of the Sacramento–San Joaquin Delta. The Delta is at the confluence of the Sacramento and San Joaquin rivers and smaller rivers entering the Delta from the east. About 80% of modern Delta inflow comes from the Sacramento River (Prokopovitch, 1985). Intertidal organic deposits began to accumulate in the Delta

S. Rojstaczer, Dep. of Geology, Duke Univ., Box 90230, Durham, NC 27708; and S.J. Deverel, U.S. Geological Survey, Water Resources Division, 2800 Cottage Way, Sacramento, CA 95825. Received 11 Mar. 1994. \*Corresponding author.

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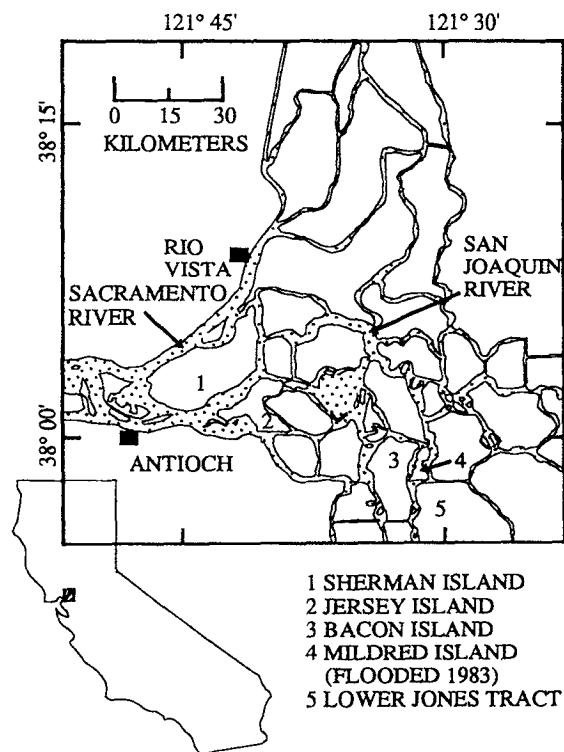


Fig. 1. Location and geographic features of the Sacramento-San Joaquin Delta.

about 7000 yr ago (Shlemon and Begg, 1975). Intertidal deposits spread across pre-Holocene alluvial and eolian deposits in the Delta as the result of the Holocene rise in relative sea level. This sea-level rise began to affect deposition in the Delta between 11000 and 7000 yr ago (Atwater et al., 1977). The organic sediments were derived primarily from the decomposition of tules, bulrushes (*Scirpus* spp.) and reeds (*Phragmites* spp.) (Atwater, 1980).

Before the California Gold Rush of the 1850s, the Delta was composed of about 1,400 km<sup>2</sup> of marshes and swamps that were subjected to tidal inundation (Gilbert, 1917). Beginning in the latter part of the 19th century, levees were constructed and the area was drained for agriculture. The Delta took on its current form by the 1930s, when drainage of 100 islands and tracts and construction of about 2250 km of levees was completed (Thompson, 1957). Water levels on the islands generally are now maintained at 1 to 2 m below land surface by networks of drainage ditches.

Drainage has caused the organic soils to oxidize and subside. Land-surface elevations of the leveed islands are now significantly below sea level (California Department of Water Resources, 1980, 1986). Several studies have made estimates of subsidence rates in the Delta. Historical rates range from 2.8 to 11.7 cm yr<sup>-1</sup>, with the higher rates generally associated with the central Delta (Weir, 1950; Prokopovitch, 1985; California Department of Water Resources, 1986). Rojstaczer and Deverel (1993) showed that mean annual subsidence rates of the three islands examined by Weir (1938, 1950) have slowed with time.

The USDA Soil Conservation Service (unpublished preliminary maps of the region) described five soil regimes in the Delta: (i) Sacramento River deltaic deposits deposited prior to the 1850s and deposited onto peat because of hydraulic mining after the 1850s; (ii) deep organic soils in the middle

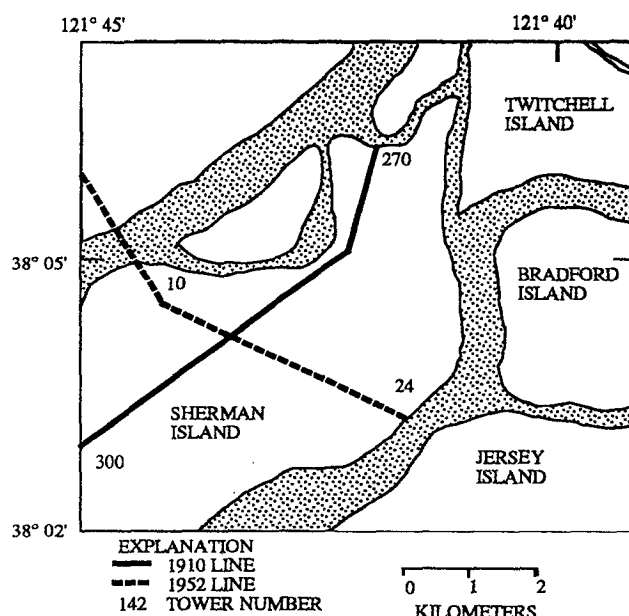


Fig. 2. Locations of 1910 and 1952 electrical transmission power lines.

of the Delta; (iii) soils developed in saline intertidal areas; (iv) soils developed from fluvial silts and clays along the eastern border of the Delta; and (v) soils developed from the San Joaquin River deltaic deposits.

In the western Delta, islands bordering the Sacramento River are composed of soils that primarily are mineral, mineral-organic complexes, and organic. The soils on these islands are predominantly organic toward the center and eastern parts of the island. The soils in the western parts and on the margins of the islands generally are mineral and mineral-organic associations. Islands in the central Delta are composed almost entirely of organic soils.

In general, strictly mineral soils occupy a network of mineral ridges along major, naturally occurring streams. Along the slopes of these streams, the lower positions are occupied by an admixture of fine-textured mineral sediments and organic matter. In the low-lying areas in the center of the islands, organic soils predominate (Cosby, 1941). Because of the higher organic matter content of the soils in the interior of the islands, many of the islands have developed a saucer shape, apparently because of the greater subsidence where organic matter contents are higher (Thompson, 1957). Cosby (1941) reported values ranging from 33 to 83% organic matter for organic soil samples collected during the 1930s.

### Methods for Evaluating Changes in Land-Surface Elevations

In the western Delta, changes in land-surface elevation relative to electrical transmission tower foundations were measured by positioning a level in the field adjacent to each of the four foundations supporting the tower. The measurements were made during July 1988. The average of the four measurements was compared with the average foundation heights of the towers when they were first constructed. Locations of the 1910 and 1952 electrical transmission power lines on Sherman Island are shown in Fig. 2. Historical foundation heights were obtained from blueprints provided by Pacific Gas and Electric Company. For the 1910 power lines, a generalized blueprint applicable to all tower foundations was available. The foundations were intended to be installed with 60 cm of concrete

exposed above the land surface. Errors in measurement for the 1910 data probably are about  $\pm 30$  cm because of the possibility that foundation installation was different from the blueprint. The error associated with the 1952 data is less than the error associated with the 1910 data because the blueprints for each foundation showed the land-surface elevations relative to the foundation during construction. Measurements were made at most foundations along the transects shown. Some foundations were not measured because of inaccessibility or because the original foundations had been replaced since the 1910 and 1952 installations.

To evaluate land subsidence in the central Delta, we examined transect surveys on Bacon Island, Lower Jones Tract, and Mildred Island following the route shown in Fig. 3. The surveys were conducted between 1922 and 1981 (Weir, 1950). Field notes for all the surveys were obtained from the California Department of Water Resources (Begg and Carlton, 1981, unpublished data). Most of the field notes contained information about the crops grown along the transect. Closure difference for the surveys ranged from 1.2 to 12.8 cm. Weir (1950) considered a closure error of 9.1 cm acceptable due to the difficult leveling conditions. We assumed that the error was randomly distributed along the 13.3-km survey transect. Surveys were referenced to a benchmark on the levee at the southwest corner of Lower Jones Tract.

Soil samples were collected adjacent to the foundations on Sherman Island in 1990 at depths of 30 and 60 cm. These depths were selected so that samples would be below the depth of active tilling and near the maximum elevation of the water table. The organic matter content of all soil samples was determined by residue loss on ignition at 550°C.

## RESULTS AND DISCUSSION

### Subsidence Estimated from Electrical Transmission Tower Foundations

We estimated historical subsidence by measuring changes in land-surface elevation in July 1988 at tower

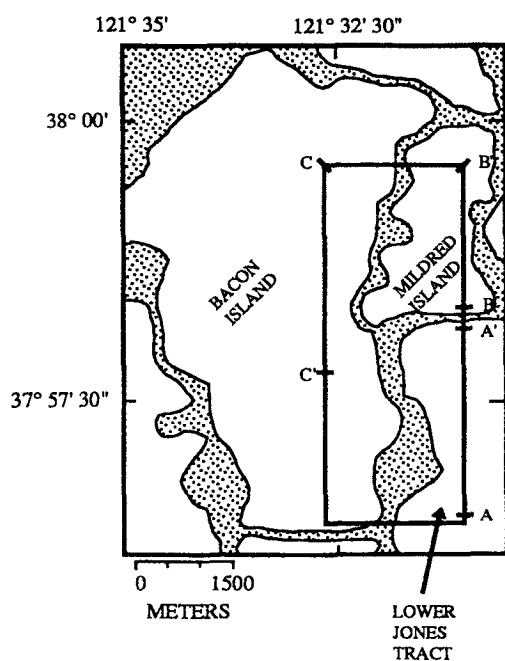


Fig. 3. Location and route of transect survey (Weir, 1950) and location of sections shown in Fig. 6.

foundations constructed in 1910 and 1952. The measurements at the foundations serve as subsidence estimates because they are mounted on pilings that were driven to refusal below the organic soil layer. We evaluated spatially variable subsidence rates in relation to the distribution of soil types, organic matter content of soil, and the locations of the foundations. The total amount of subsidence estimated from measurements of towers constructed in 1910 and 1952 are shown in Fig. 4. In our subsidence estimates, we assumed that the tower foundations have not changed in elevation with time.

On Sherman Island, the foundations were increasingly exposed toward the center of the island, showing a maximum amount of subsidence of 240 cm from 1910 to 1988. For the data from the towers constructed in 1910, the median subsidence rate on Sherman Island was 2.3 cm yr<sup>-1</sup>. Data from the towers constructed in 1952 indicate a maximum amount of subsidence of 122 cm and a median subsidence rate of 1.5 cm yr<sup>-1</sup>. Comparison of the 1910 and 1952 tower elevations suggests that the rate of subsidence is slowing with time. The rate calculated from the 1952 towers is significantly lower ( $\alpha = 0.01$ ) than the rate calculated from the 1910 towers, as determined by the Wilcoxon rank sum test (Hollander and Wolfe, 1973). The apparent slowing in subsidence rate may also be attributable to differences in organic content between the soils encountered along the 1910 and 1952 towers.

We assessed the spatial variability in subsidence on Sherman Island by evaluating the amounts of subsidence

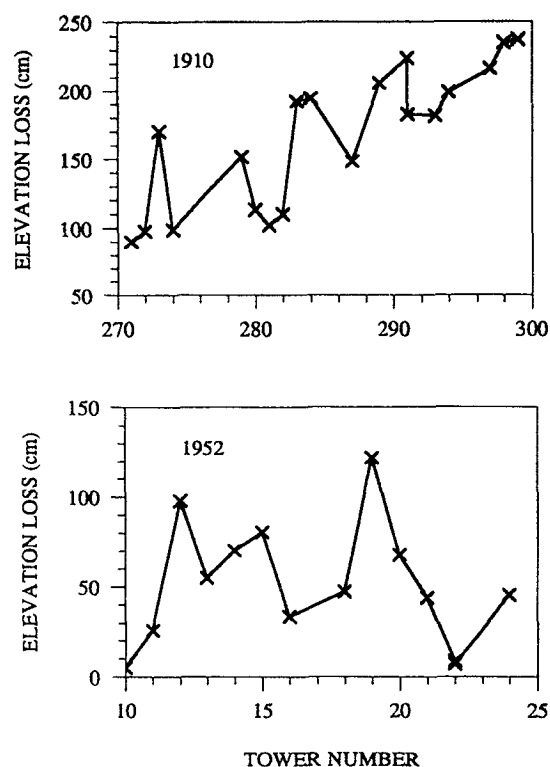


Fig. 4. Cumulative average amount of subsidence as of July 1988 at electrical transmission towers since 1910 and 1952. Locations of transmission lines shown in Fig. 2.

in relation to the organic matter content of soil, the soil type adjacent to the tower foundations, and the distance of the foundation from the levee. For the 1910 foundation data, subsidence rates for the different organic matter contents were <20% organic matter, 0.64 to 2.16 cm yr<sup>-1</sup>; 20 to 30% organic matter, 1.00 to 3.02 cm yr<sup>-1</sup>; and >30% organic matter, 1.54 to 2.85 cm yr<sup>-1</sup>. For the 1952 foundation data, organic matter contents ranged from 14 to 48% and subsidence rates ranged from 0.19 cm yr<sup>-1</sup> at the site with 14% organic matter content to 2.26 cm yr<sup>-1</sup> at a site with 48% organic matter. It should be noted that the organic matter content of the soil was significantly higher at the time of the 1910 tower installation.

Figure 5a shows the relation of the mean organic matter content of the samples collected at the 30- and 60-cm depths adjacent to the 1910 foundations to the estimated subsidence. It should be noted that there is generally a poor correlation between the organic matter content of the soils as defined by soil taxonomy and the mapped soil types and no trends in organic matter content with depth were observed. The organic matter content is significantly correlated ( $\alpha = 0.01$ ) with subsidence

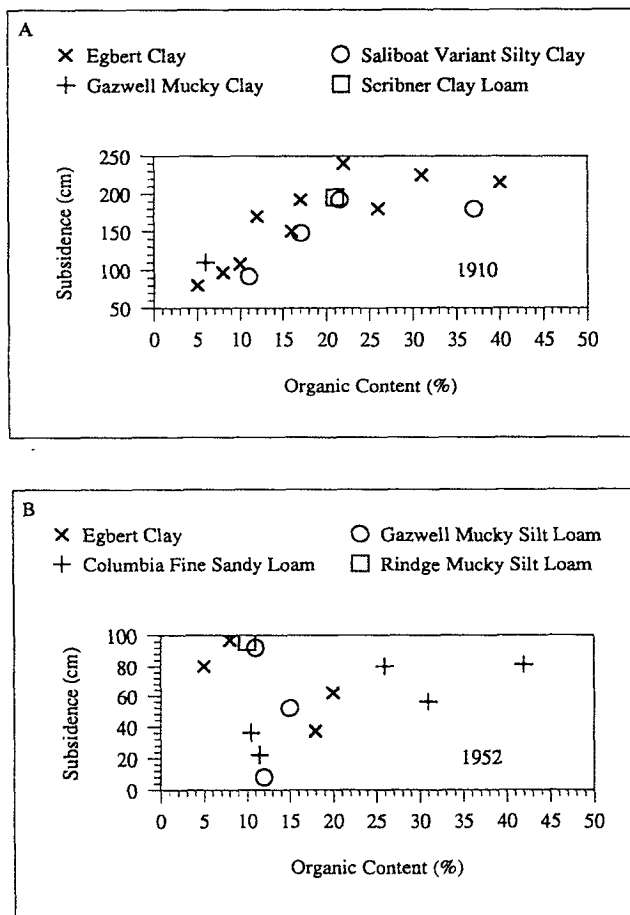


Fig. 5. Relation of average amount of subsidence and average organic matter content of soil in 1990 at electrical transmission towers of (A) 1910 and (B) 1952. Note that there is generally a poor correlation between the organic matter content of the soils as defined by soil taxonomy and the mapped soil types.

and explains 62% of the variance. Samples with the highest organic matter content were collected farthest from the levees, whereas the samples with the lowest organic matter content were collected closest to the levees.

Figure 5b shows the relation of the organic matter content and the amount of subsidence for the 1952 foundation data. Organic matter content generally increased with increasing subsidence, except for one location where subsidence was substantial but organic matter was low. The soil series at this location is associated with (overlying or underlying) organic soils. This soil may have been overlain by organic soils that completely oxidized.

The distribution of soil series on Sherman Island is consistent with the spatially variable subsidence and the distribution of organic matter contents of soil and reflects the island's depositional history. The organic soils, Rindge mucky silt loam (euic, thermic Typic Medisaprist) and Gazwell mucky silt loam (fine, mixed, thermic Cumulic Haplaquoll), predominate in the center of the island with organic matter contents ranging from 10 to 50%. Mineral soils, Columbia fine sandy loam (coarse-loamy, mixed, nonacid, thermic Aquic Xerofluvent) and Egert clay (fine, mixed, thermic Cumulic Haplaquoll), probably deposited as natural levees, predominate along the edges of the island. These two soils also predominate where there was a levee break near the turn of the century (Thompson, 1957). The organic-mineral associations, Sailboat variant silty clay (fine-loamy, mixed, nonacid, thermic Aquic Xerofluvent) and Scribner clay loam (fine-loamy, mixed, thermic Cumulic Haplaquoll), primarily are in areas downslope of the natural levees and tend to be confined to narrow channels. As a result of being on the western edge of the Delta (Fig. 1), Sherman Island has been subject to deposition from the Sacramento and San Joaquin rivers. This is reflected in the variability in soil series. Subsidence and organic matter contents of soil are the lowest near the levees because of fluvial deposition of mineral material. Higher organic matter contents toward the center of the island resulted in greater subsidence.

### Subsidence Estimated from Leveling Surveys

Subsidence measured by leveling along the transect shown in Fig. 3 began in 1922 (Weir, 1950). In an earlier study, we examined mean annual subsidence rates for each of the three islands included in the transect and noted that mean annual subsidence rates have declined with time (Rojstaczer and Deverel, 1993). In this study, we examined the transect data for temporal and spatial trends in subsidence relative to cropping patterns. The California Department of Water Resources (1980) indicated that different agricultural practices associated with different crops could affect local subsidence rates, but they were not able to confirm this with available data. Where practiced, they estimated that burning of soil organic matter could result in 0.2 to 0.3 cm yr<sup>-1</sup> of subsidence.

Subsidence histories were constructed for each of the islands along the transect. To construct subsidence histor-

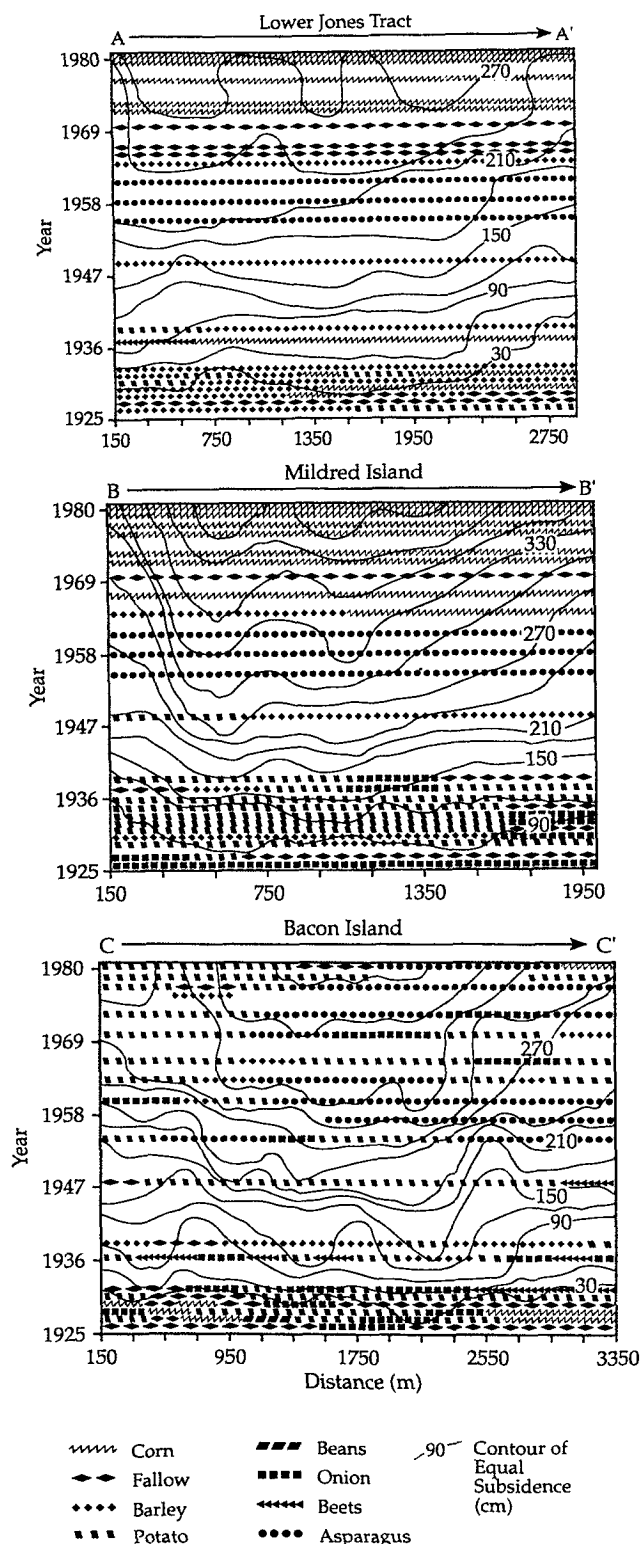


Fig. 6. Spatial variation of subsidence and land-use histories along sections of the transect, 1925 to 1981: (A) Lower Jones Tract, section A-A' in Fig. 3; (B) Mildred Island, section B-B'; (C) Bacon Island, section C-C'.

ies, the 1925 survey (Weir, 1950) was used as the base elevation. Elevation data from subsequent surveys were

subtracted from the base elevation to determine elevation changes since 1925. Figure 6 shows the spatial variations of subsidence and land-use histories from 1925 to 1981 along sections of the transect on Lower Jones Tract, Mildred Island, and Bacon Island. The contours represent the cumulative elevation loss for the years of measurement. Areas with high subsidence rates appear as troughs, and areas with low subsidence rates appear as crests.

While there is significant variability in subsidence rates over time and space, two trends can be identified on all three islands. Contour spacing in Fig. 6 tends to widen with time. This widening is consistent with a declining subsidence rate. The one notable exception occurs between 1938 and 1948 where the contours, particularly in the center of the island, are clustered, implying an increased rate of subsidence during this time. Data regarding land use are not available, as the transect was not surveyed between 1938 and 1948. However, Thompson (1957) observed that sugar beet (*Beta vulgaris* L. ssp. *vulgaris*) and potato (*Solanum tuberosum* L.) were the predominant crops grown in the Delta during World War II (1939–1945) due to the wartime demand for these products. Fields with organically rich soils to be planted to these crops were often burned to increase the ash content and control weeds (Cosby, 1941). Controlled burning was apparently a common practice in the Delta throughout the war years (Thompson, 1957). When organic soil is burned, as much as the top 8 cm of soil can burn (Weir, 1950). The increased subsidence rates measured on Mildred Island and Lower Jones Tract between 1938 and 1948 may be the result of burning. The rates of subsidence during this time period are generally >50% greater than subsidence rates the decade following. If burning is the sole cause of the change, then it is responsible for >1 cm of subsidence per year during this time period.

A historically persistent trough, indicating an area of increased subsidence, occurs toward the center of the transect along both Mildred and Bacon Islands. On Mildred Island, the subsidence trend cannot be correlated with a particular crop type: for any given year, crop type along the transect was virtually uniform. Also, there was no apparent relation between crop type and subsidence for the Bacon Island data. With the possible exception of burning, cultivation and cropping practices do not seem to affect subsidence rates on these three islands. Presumably, spatial trends in subsidence on these islands, similar to Sherman Island, are due to primarily to trends in organic content of the soil.

## CONCLUSIONS

Historical measurements of spatially variable subsidence in the Sacramento–San Joaquin Delta were assessed in relation to varying land use and the organic matter contents of the soil. The results of this assessment indicate that: (i) spatially variable subsidence is correlated with organic matter content of the soil, which in turn is related to the depositional and drainage history of the islands; and (ii) different cropping practices do not seem to affect subsidence rates.

These results have significant implications for land use management in areas with extensive Histosols. Although Histosols are valuable for agriculture, their use, especially in coastal regions, can be expected to have a significant environmental impact. It would require the maintenance of a high water table in critical areas with soils of extremely high organic content. In some areas, these land use restrictions may severely limit the viability of agricultural use of Histosols. Extensive acreage may have to be converted to wetland status.

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